ABSTRACT

Writing music with SAS® is a simple process. Including a snippet of “music” in a program is a great way to signal completion of processing. It’s also fun! This paper illustrates a method for translating music into SAS® code using the CALL SOUND routine.

BACKGROUND

All musical notes are based on two primary parameters:

- Frequency
- Duration

The CALL SOUND routine generates a sound with a specific frequency and duration using the following syntax:

- CALL SOUND(frequency,duration);
- Required arguments:
  - frequency – specifies the sound frequency in terms of cycles per second. The frequency must be at least 20 and no greater than 20,000.
  - duration – specifies the sound duration in milliseconds. The default is -1.

Example:

- The following statement will play “middle C” for 2 seconds:

```sas
data _null_
  call sound(261.63,2000)
run;
```

Refer to Exhibit 1 for the frequencies for nine octaves of notes.

EXAMPLE

The Symphony No. 5 in C minor by Ludwig van Beethoven, Op. 67 is one of the best-known compositions in classical music. It begins with a distinctive four-note “short-short-short-long” motif twice:

In the first measure, the G note is played three times, followed by E flat in the second measure. In the third measure, the F note is played three times followed by D which is sustained for two measures. Translating these notes to the CALL SOUND routine is a straightforward look-up from the table in Exhibit 1, recalling that middle C (which is highlighted in the table) is 261.63 Hz. After entering the frequency value for each note, enter values for duration, keeping in mind that musical note and rest values are not absolutely defined, but are proportional in duration to all other note and rest values. The whole note is the reference value, and the other notes are named in comparison; i.e., a half note is half the length of a whole note.
In the five measures above, we have the following sequence of notes:

- Three G eighth notes
- E flat half note, with a pause accent symbol above it
- Three F eighth notes
- D half note, sustained for two measures with a pause

For this piece of music we will define note durations as follows:

<table>
<thead>
<tr>
<th>Note</th>
<th>Milliseconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole</td>
<td>1000</td>
</tr>
<tr>
<td>Half</td>
<td>500</td>
</tr>
<tr>
<td>Eighth</td>
<td>125</td>
</tr>
<tr>
<td>Sixteenth</td>
<td>62.5</td>
</tr>
</tbody>
</table>

Using this table as a starting point, and by applying some “artistic license”, we make duration assignments as follows:

- Three G eighth notes: 125 millisecond duration for each
- E flat half note, with a pause accent symbol above it: Typically 500 milliseconds, but we will extend it to 1200 milliseconds based on the “pause” notation.
- Three F eighth notes: 125 millisecond duration for each
- D half note, sustained for two measures with a pause: Typically 500 milliseconds, but we will extend to a total of 1600 milliseconds based on the “pause” notation.

Here’s what the SAS® statements look like:

```sas
*& Beethoven: Symphony No.5 in C Minor;
data _null_;  
call sound(392, 125);  
call sound(392, 125);  
call sound(392, 125);  
call sound(311.13, 1200);  
call sound(349.23, 125);  
call sound(349.23, 125);  
call sound(349.23, 125);  
call sound(293.66, 1600);  
run;
```

See Exhibit 2 for more examples.

**CONCLUSION**

This brief introduction to a simple coding technique is intended to encourage SAS programmers to have a little fun. You don’t need to know how to read music to experiment with adding some “tone” to your programs. Just use your ear and tweak the code until it sounds right. Give it a try!

**REFERENCES**

Suits, B. H. “Frequencies for equal-tempered scale, \( A_4 = 440 \text{ Hz} \).” Available at http://www.phy.mtu.edu/~suits/notefreqs.html.
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## Exhibit 1

### Table of Musical Notes and Frequencies

<table>
<thead>
<tr>
<th>Note</th>
<th>Frequency (Hz)</th>
<th>Note</th>
<th>Frequency (Hz)</th>
<th>Note</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₀</td>
<td>16.35</td>
<td>C₃</td>
<td>130.81</td>
<td>C₆</td>
<td>1046.50</td>
</tr>
<tr>
<td>C₆/G₇</td>
<td>17.32</td>
<td>C₃/D₅</td>
<td>138.59</td>
<td>C₆/D₇</td>
<td>1108.30</td>
</tr>
<tr>
<td>D₀</td>
<td>18.35</td>
<td>D₃</td>
<td>146.83</td>
<td>D₆</td>
<td>1174.66</td>
</tr>
<tr>
<td>D₆/E₇</td>
<td>19.45</td>
<td>D₃/E₅</td>
<td>155.56</td>
<td>D₆/E₇</td>
<td>1244.51</td>
</tr>
<tr>
<td>E₀</td>
<td>20.60</td>
<td>E₃</td>
<td>164.81</td>
<td>E₆</td>
<td>1318.51</td>
</tr>
<tr>
<td>F₀</td>
<td>21.83</td>
<td>F₃</td>
<td>174.61</td>
<td>F₆</td>
<td>1396.91</td>
</tr>
<tr>
<td>F₆/G₇</td>
<td>23.12</td>
<td>F₃/G₅</td>
<td>185.00</td>
<td>F₆/G₇</td>
<td>1479.98</td>
</tr>
<tr>
<td>G₀</td>
<td>24.50</td>
<td>G₃</td>
<td>196.00</td>
<td>G₆</td>
<td>1567.98</td>
</tr>
<tr>
<td>G₆/A₇</td>
<td>25.96</td>
<td>G₃/A₅</td>
<td>207.65</td>
<td>G₆/A₇</td>
<td>1661.22</td>
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<tr>
<td>A₀</td>
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<td>A₃</td>
<td>220.00</td>
<td>A₆</td>
<td>1760.00</td>
</tr>
<tr>
<td>A₆/B₈</td>
<td>29.14</td>
<td>A₃/B₅</td>
<td>233.08</td>
<td>A₆/B₈</td>
<td>1864.66</td>
</tr>
<tr>
<td>B₀</td>
<td>30.87</td>
<td>B₃</td>
<td>246.94</td>
<td>B₆</td>
<td>1975.53</td>
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<tr>
<td>C₁</td>
<td>32.70</td>
<td>C₄</td>
<td>261.63</td>
<td>C₇</td>
<td>2093.00</td>
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<tr>
<td>C₇/D₈</td>
<td>34.65</td>
<td>C₄/D₆</td>
<td>277.18</td>
<td>C₇/D₈</td>
<td>2217.46</td>
</tr>
<tr>
<td>D₁</td>
<td>36.71</td>
<td>D₄</td>
<td>293.66</td>
<td>D₇</td>
<td>2349.32</td>
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<td>D₇/E₉</td>
<td>38.89</td>
<td>D₄/E₆</td>
<td>311.13</td>
<td>D₇/E₉</td>
<td>2489.02</td>
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<tr>
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<td>F₄</td>
<td>349.23</td>
<td>F₇</td>
<td>2793.83</td>
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<tr>
<td>F₇/G₉</td>
<td>46.25</td>
<td>F₄/G₇</td>
<td>369.99</td>
<td>F₇/G₉</td>
<td>2959.96</td>
</tr>
<tr>
<td>G₁</td>
<td>49.00</td>
<td>G₅</td>
<td>392.00</td>
<td>G₇</td>
<td>3135.96</td>
</tr>
<tr>
<td>G₇/A₁₀</td>
<td>51.91</td>
<td>G₅/A₇</td>
<td>415.30</td>
<td>G₇/A₁₀</td>
<td>3322.44</td>
</tr>
<tr>
<td>A₁</td>
<td>55.00</td>
<td>A₅</td>
<td>440.00</td>
<td>A₇</td>
<td>3520.00</td>
</tr>
<tr>
<td>A₇/B₁₁</td>
<td>58.27</td>
<td>A₅/B₈</td>
<td>466.16</td>
<td>A₇/B₁₁</td>
<td>3729.31</td>
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<tr>
<td>B₁</td>
<td>61.74</td>
<td>B₅</td>
<td>493.88</td>
<td>B₇</td>
<td>3951.07</td>
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<tr>
<td>C₂</td>
<td>65.41</td>
<td>C₅</td>
<td>523.25</td>
<td>C₈</td>
<td>4186.01</td>
</tr>
<tr>
<td>C₈/D₁₀</td>
<td>69.30</td>
<td>C₅/D₈</td>
<td>554.37</td>
<td>C₈/D₁₀</td>
<td>4434.92</td>
</tr>
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<td>D₂</td>
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<td>587.33</td>
<td>D₉</td>
<td>4698.63</td>
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<td>D₉/E₁₁</td>
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<td>D₅/E₉</td>
<td>622.25</td>
<td>D₉/E₁₁</td>
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<td>F₅</td>
<td>698.46</td>
<td>F₉</td>
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<td>F₉/G₁₁</td>
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<td>F₅/G₉</td>
<td>739.99</td>
<td>F₉/G₁₁</td>
<td>5919.91</td>
</tr>
<tr>
<td>G₂</td>
<td>98.00</td>
<td>G₅</td>
<td>783.99</td>
<td>G₉</td>
<td>6271.93</td>
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<td>G₉/A₁₂</td>
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<td>G₅/A₉</td>
<td>830.61</td>
<td>G₉/A₁₂</td>
<td>6644.88</td>
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<tr>
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<td>A₅</td>
<td>880.00</td>
<td>A₉</td>
<td>7040.00</td>
</tr>
<tr>
<td>A₉/B₁₃</td>
<td>116.54</td>
<td>A₅/B₇</td>
<td>932.33</td>
<td>A₉/B₁₃</td>
<td>7458.62</td>
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<td>B₂</td>
<td>123.47</td>
<td>B₅</td>
<td>987.77</td>
<td>B₈</td>
<td>7902.13</td>
</tr>
</tbody>
</table>
Exhibit 2
Examples

Note: A simple method for inserting a rest (i.e., an interval of "silence) into a piece of music is to select a very high or low frequency that the human ear cannot hear, as you can see in several of the examples below.

* Deep Purple: Smoke on the Water ;
  data _null_;  
    call sound(196, 300);  
    call sound(233.08, 300);  
    call sound(261.63, 600);  
  call sound(196, 300);  
  call sound(233.08, 300);  
  call sound(261.63, 600);  
  call sound(277.18, 150);  
  call sound(261.63, 600);  
  call sound(196, 300);  
  call sound(233.08, 300);  
  call sound(261.63, 600);  
  call sound(233.08, 300);  
  call sound(196, 900);  
run;

* George Thorogood: Bad To the Bone ;
  data _null_;  
    call sound(440, 100);  
    call sound(440, 100);  
    call sound(587.33, 100);  
    call sound(440, 100);  
    call sound(523.25, 100);  
    call sound(440, 800);  
  call sound(440, 100);  
  call sound(440, 100);  
  call sound(587.33, 100);  
  call sound(440, 100);  
  call sound(523.25, 100);  
  call sound(440, 800);  
  call sound(440, 100);  
  call sound(440, 100);  
  call sound(587.33, 100);  
  call sound(440, 100);  
  call sound(523.25, 100);  
  call sound(440, 800);  
run;
* Cream:  Sunshine of Your Love ;
  data _null_;  
  call sound(587.33, 150);  
  call sound(587.33, 150);  
  call sound(523.25, 150);  
  call sound(587.46, 300);  
  call sound(440, 300);  
  call sound(415.30, 300);  
  call sound(392, 300);  
  call sound(587.33, 150);  
  call sound(698.46, 500);  
  call sound(587.33, 300);  
  run;

* Queen:  We Will Rock You ;
  data _null_;  
  call sound(392, 400);  
  call sound(369.99, 400);  
  call sound(329.63, 400);  
  call sound(293.96, 400);  
  call sound(329.63, 200);  
  call sound(329.63, 200);  
  call sound(16.35, 1200);  
  call sound(392, 400);  
  call sound(369.99, 400);  
  call sound(329.63, 400);  
  call sound(293.96, 400);  
  call sound(329.63, 200);  
  call sound(329.63, 200);  
  call sound(16.35, 1200);  
  run;

* Shania Twain:  Man! I Feel Like a Woman! ;
  data _null_;  
  call sound(440, 200);  
  call sound(440, 400);  
  call sound(440, 150);  
  call sound(369.99, 300);  
  call sound(329.63, 200);  
  call sound(440, 200);  
  call sound(440, 300);  
  run;
* AC/DC:  Highway To Hell ;
data _null_;  
call sound(440, 200);  
call sound(440, 200);  
call sound(440, 600);  
call sound(369.9, 200);  
call sound(369.2, 200);  
call sound(392, 400);  
call sound(369.9, 200);  
call sound(369.2, 200);  
call sound(392, 400);  
call sound(369.9, 200);  
call sound(369.2, 200);  
call sound(392, 400);  
call sound(369.9, 200);  
call sound(369.2, 200);  
call sound(392, 400);  
call sound(369.9, 200);  
call sound(440, 200);  
call sound(440, 600);  
run;

* Beatles:  She Loves You ;  
data _null_;  
call sound(587.33, 100);  
call sound(659.25, 200);  
call sound(783.99, 200);  
call sound(783.99, 400);  
call sound(739.99, 300);  
call sound(659.25, 400);  
  
* pause - note you cannot hear ;  
call sound(16.35, 15);  
call sound(587.33, 100);  
call sound(659.25, 200);  
call sound(783.99, 200);  
call sound(783.99, 400);  
call sound(739.99, 300);  
call sound(659.25, 400);  
  
* pause - note you cannot hear ;  
call sound(16.35, 15);  
call sound(587.33, 100);  
call sound(659.25, 200);  
call sound(783.99, 200);  
call sound(783.99, 400);  
call sound(739.99, 400);  
call sound(659.25, 400);  
call sound(587.3, 1000);  
run;
* Led Zeppelin: Immigrant Song *

data _null_;  
call sound(369.99, 100);  
call sound(369.99, 50);  
call sound(369.99, 50);  
call sound(739.99, 100);  
call sound(369.99, 100);  
call sound(369.99, 50);  

call sound(369.99, 100);  
call sound(369.99, 50);  
call sound(369.99, 50);  
call sound(739.99, 100);  
call sound(369.99, 100);  
call sound(369.99, 50);  

call sound(369.99, 100);  
call sound(369.99, 50);  
call sound(369.99, 50);  
call sound(739.99, 100);  
call sound(369.99, 100);  
call sound(369.99, 50);  

call sound(369.99, 100);  
call sound(369.99, 50);  
call sound(369.99, 50);  
call sound(739.99, 100);  
call sound(369.99, 100);  
call sound(369.99, 50);  

run;

* Led Zeppelin: Stairway To Heaven *

data _null_;  
call sound(880, 200);  
call sound(1046.56, 200);  
call sound(1318.51, 200);  
call sound(1760, 200);  
call sound(1975.53, 800);  
call sound(1975.53, 200);  
call sound(2093, 800);  
call sound(2093, 200);  
call sound(1479.98, 800);  
call sound(1396.91, 200);  
call sound(1318.51, 200);  
call sound(1046.56, 200);  
call sound(880, 400);  
call sound(1318.51, 200);  
call sound(1046.56, 200);  
call sound(880, 200);  
call sound(880, 1200);  
run;